Competency 2.9 **Radiation protection personnel shall demonstrate a familiarity level knowledge of the Federal regulations, guidelines, and Department of Energy (DOE) Orders pertaining to the decontamination and decommissioning of nuclear facilities.**

1. SUPPORTING KNOWLEDGE AND/OR SKILLS

a. Discuss the application of the Department's Guidelines for Formerly Utilized Sites Remedial Action Program (FUSRAP) established in 1974 and the Surplus Facilities Management Program (SFMP) established in 1978.

b. Discuss the role of radiation protection personnel with respect to the Radiological Guidelines for Application to the Department's Formerly Utilized Sites Remedial Action Program (ORO-831, March 1983).

c. Discuss the contents, responsibilities, and requirements contained in DOE/EM-0246, *Decommissioning Resource Manual*.

d. Discuss the contents of DOE/EM-0142P, *Decommissioning Handbook.*

2. SUMMARY

Formerly Utilized Sites Remedial Action Program (FUSRAP)

During the 1940s and 1950s, U.S. Army Corps of Engineers Manhattan Engineer District (MED) and its successor, the U.S. Atomic Energy Commission (AEC), conducted a program involving research, development, processing, and production of uranium and thorium. Storage of radioactive ores and processing residues (e.g., mill tailing) was also included in this program. Most of this work was performed by private contractors for the government on land that was either federally, privately, or institutionally owned.

This early, rather large, nuclear program was conducted with a great sense of urgency and limited available knowledge regarding the radioactive characteristics of uranium ore and the residual material produced from its processing. Therefore, many of these sites became contaminated with radioactivity.

DOE implemented a program to evaluate and, where necessary, take action to protect the public from contamination at sites that were used in the past to process and/or store radioactive materials for the former MED or the AEC. This program is identified as FUSRAP.

FUSRAP formally began in 1974. Radiological surveys and other research work had been conducted by the AEC and its successors, the Energy Research and Development Administration (ERDA) and DOE, under the implied authority of the Atomic Energy Act of 1954, as amended. The intent of Congress, as expressed in the FY 1978 DOE Authorization Act, was that, at the completion of this program, DOE would seek additional legislative authority, pursuant to a Congressional review of findings, for the undertaking of any required remedial action work. The objectives of FUSRAP were to:

- Identify former MED/AEC sites.
- Characterize their radiological condition.
- Decontaminate the sites as required and pursuant to authorization and appropriation by Congress.
- Develop acceptable disposal and stabilization sites in consultation with the affected states.
- Certify the acceptability of the sites for future use.

In 1978, the Surplus Facilities Management Program (SFMP) was established for the coordinated management of the decommissioning of surplus contaminated DOE facilities. The Richland Program Office issued the *SFMP Resource Manual* to serve as the management guide. The principal directive for the program was DOE Order 5820.2, *Radioactive Waste Management*. Radiological release criteria were established on a case-by-case basis in conformance with DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. In 1982, the single program was divided. The civilian (or nuclear energy) program, which continued to be managed by the SFMP, relocated to DOE

Headquarters in Washington, DC. For surplus facilities from the national defense programs, decommissioning was directed through the Defense Facilities Decommissioning Program Office located in Richland, WA.

The *SFMP Resource Manual* continued to be the principal management guidance for the civilian program. The defense program issued DOE/RL-89-93, *Defense Decontamination and Decommissioning Program: Program Management Plan.*

FUSRAP is now subject to the provisions of NEPA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE must reach agreement with EPA and state regulators on how and when the cleanup is to occur. FUSRAP includes 46 sites nationwide, many of which are located in the northeastern part of the country. As of early 1996, cleanup has been completed on 20 of the sites.

ORO-831, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program* (March 1983), described methods considered appropriate for the evaluation of health effects that might possibly be caused by radioactive, contamination at FUSRAP sites. This assessment methodology was applied to a typical site for the purpose of deriving guidelines for the cleanup of contaminated soil. Therefore, the purpose of ORO-831 was to provide radiological guidelines for assessing the need for remedial action and for evaluating the sufficiency of any remedial action that might be undertaken, as well as to identify the data and methods of analysis on which these guidelines were based.

Evaluation of the most appropriate action for a FUSRAP site requires consideration of many factors. The scope of ORO-831 is limited to factors that enter into evaluation of the radiological impacts. The intent is to provide guidance for estimating radiological conditions at FUSRAP sites before remedial action, during planning of remedial action, and when evaluating conditions following remedial action. Factors such as costs of alternative actions, state and local government issues, and disposition of the residues are not evaluated; they must be addressed in appropriate documents specific to each site.

Radiological surveys of FUSRAP sites have indicated that there are various levels of radioactivity present in soils, in residues, and in or on remaining buildings. At some sites, expeditious remedial action was warranted by the levels of radioactivity, or expected future land use, and remedial actions are complete or underway at those sites. However, there still remain a number of sites where there is a need to determine the most cost-effective remedial action that provides acceptable public health protection.

The long-term risk from radioactive contamination at FUSRAP sites is that deleterious health effects may result from inhalation and ingestion of radionuclides and from exposure to external radiation. (Figure 1, following, depicts residual radioactive material exposure pathways.) Such risk can be

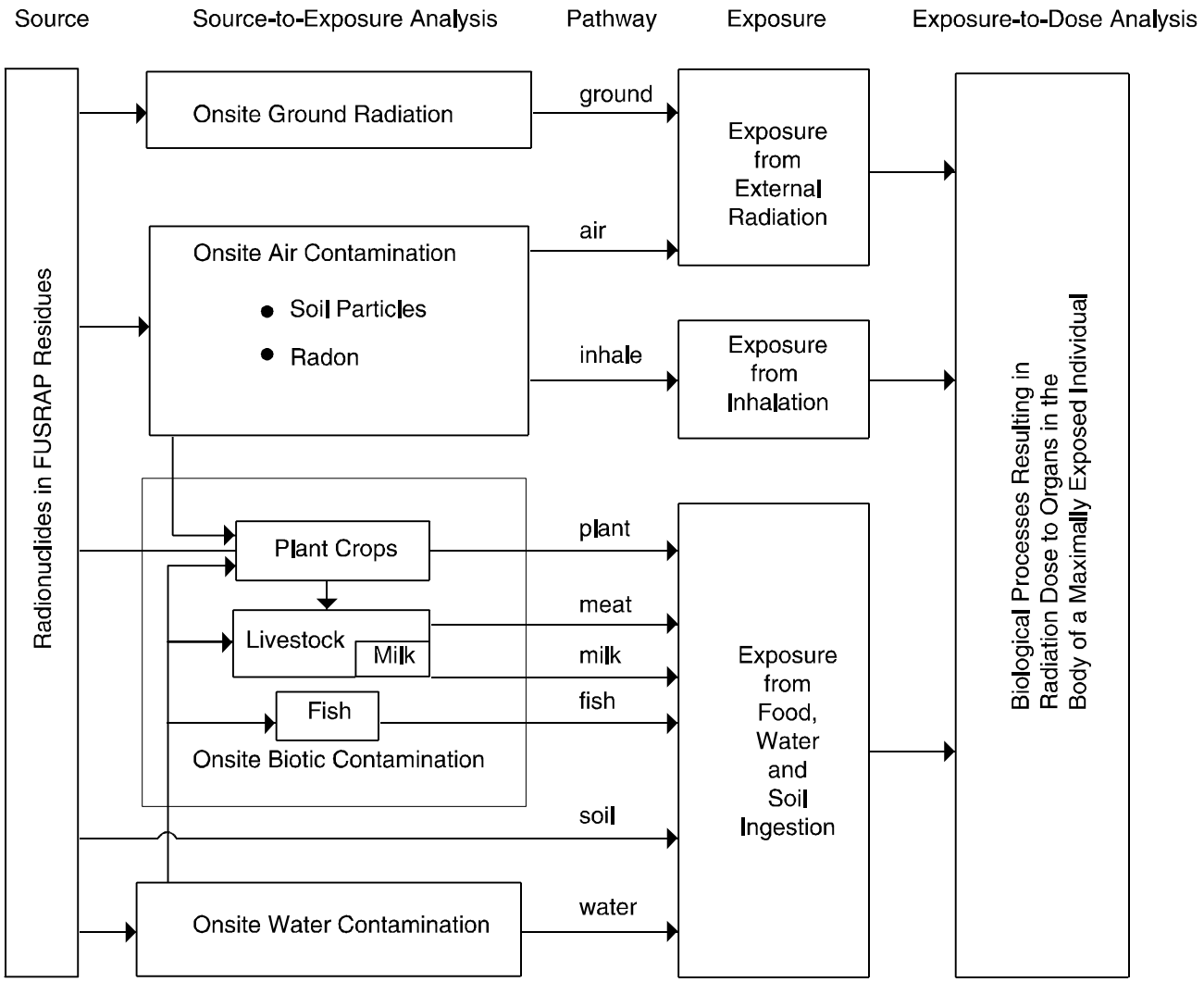
expressed as the probability of an exposed individual contracting cancer after being irradiated. The levels of radiation at FUSRAP sites are so low that the health implications can only be estimated using mathematical relationships rather than relying on direct observation of an effect on an individual, or even a large population.

Assessments of the radiological impacts require three sets of input data:

- Field measurements of the radioactivity.
- Estimates of the relationship between sources of radiation and consequent radiation doses to individuals.
- Radiation protection standards that have been developed from health risk considerations.

Field measurements provide data on beta and gamma radiation levels at different onsite locations, surface activity of alpha-emitting radionuclides on building structures, and concentrations of radionuclides in soil samples. Radionuclide concentrations in soil are usually the critical data.

Figure 1



Simplified Diagram Showing Major Pathways to Maximally Exposed Individual

Estimates of the dose/source relationship are based on a source-to-dose analysis consisting of a chain of risk-evaluation steps:

1. A determination of the source terms from field measurements (source-term analysis).
2. An analysis of the human exposure that is likely to occur as a consequence of the sources (source-to-exposure analysis).
3. An analysis of the radiation dose that will result from the exposure (exposure-to-dose analysis).
4. An analysis of the health effects that are likely to result from a given dose (dose-to-health effects analysis).

Radiation protection standards expressed in terms of dose limits are based on this fourth step. Such standards are generally applicable to all actions involving management and use of radioactive materials, and serve as a starting point for deriving FUSRAP soil-concentration guidelines that may be compared directly with measured soil concentrations. Other protection standards (e.g., limits on air and water concentrations that are based on analyses relating them to health effects) are also useful in controlling radiation exposure and dose.

DOE Order 5400.5

DOE 5400.5, *Radiation Protection of the Public and the Environment* (1990), Chapter IV, "Residual Radioactive Material," Section 1 through 5, presents:

- Radiological protection requirements and guidelines for cleanup of residual radioactive material.
- Management of the resulting wastes and residues.
- Release of property.

These requirements and guidelines are applicable at the time the property is released. Property subject to these criteria includes, but is not limited to, sites identified by FUSRAP and SFMP. The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and control of the radioactive wastes and residues. This chapter does not apply to uranium mill tailings or to properties covered by mandatory legal requirements.

Basic Dose Limits

The basic dose limit to members of the public for exposure to residual radioactive material is 100 mrem (1 mSv) effective dose equivalent, in addition to naturally occurring background exposures, in a year. For unusual circumstances, the respective project or program office may request from EH-1 an uthorization for a temporary limit higher than 100 mrem, but not greater than 500 mrem, in a year.

Guidelines for Residual Radioactive Material

In addition to guidelines for concentrations of residual radioactive material in soil, air, and water, as well as surface contamination guidelines, the following limits apply to habitable structures intended for release without restrictions:

- Airborne Radon Decay Products

  Annual average (or equivalent) concentration, including background, not to exceed 0.02 working level. In no case shall the concentration exceed 0.03 working level. (A working level is defined as any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.)

- External Gamma Radiation

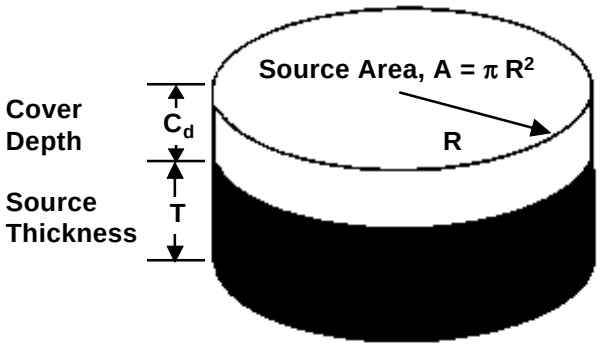
  The average level shall not exceed background levels by more than 20 µR/hr, and shall comply with the basic dose limit when an "appropriate-use" scenario is considered.

In 1989, a manual for implementing DOE's residual radioactive material guidelines was developed, and the dose assessment methodology recommended for use in deriving site-specific soil guidelines was coded in a microcomputer program called RESRAD. The DOE guidelines were incorporated into DOE Order 5400.5, in February 1990, and were included in proposed 10 CFR 834, *Radiation Protection of the Public and the Environment*, in March 1993. Since then, the manual and the code have been used widely by DOE and its contractors and, to some degree, by the U.S. Nuclear Regulatory Commission (NRC) and licensing states. Comments received from users and new features have been incorporated into the code (Version 5.61). These improvements serve to ease the user's interaction with the code while increasing RESRAD's capability and flexibility.

In evaluating potential doses from residual radioactivity, one typically assesses the acceptability of the doses by constructing a source-term and exposure scenario and executing a computer model or analytical solution that simulates the release and transport of radionuclides and radiation in the environment. These assessments are performed on a site-specific basis and reflect differences in the characteristics of the residual radioactivity (e.g., nature, types, extent, and concentrations of radioactive contaminants) and of the environment (e.g., soil, surface water, groundwater, and meteorology at the site). Unless there is a compelling reason to exclude specific exposure pathways based on these characteristics, a uniform set of exposure scenarios should be considered in evaluating whether residual radioactivity has been sufficiently reduced in accordance with regulations.

The common source term is assumed to be an uncovered contaminated soil zone of typically cylindrical shape. The radionuclide contaminants are assumed to be homogeneously distributed within the contaminated zone. (See Figure 2, following.)

Figure 2
Geometry of Idealized Contaminated Zone



Many parameters that determine the quantity of radionuclides or radiation to which an individual is exposed are determined by exposure scenarios (i.e, patterns of human activity that can affect the release of radioactivity from the contaminated zone and the amount of exposure received at the exposure location) (see Figure 3, Exposure Pathways). Three typical scenarios which are used in determining potential doses associated with residual radioactivity are:

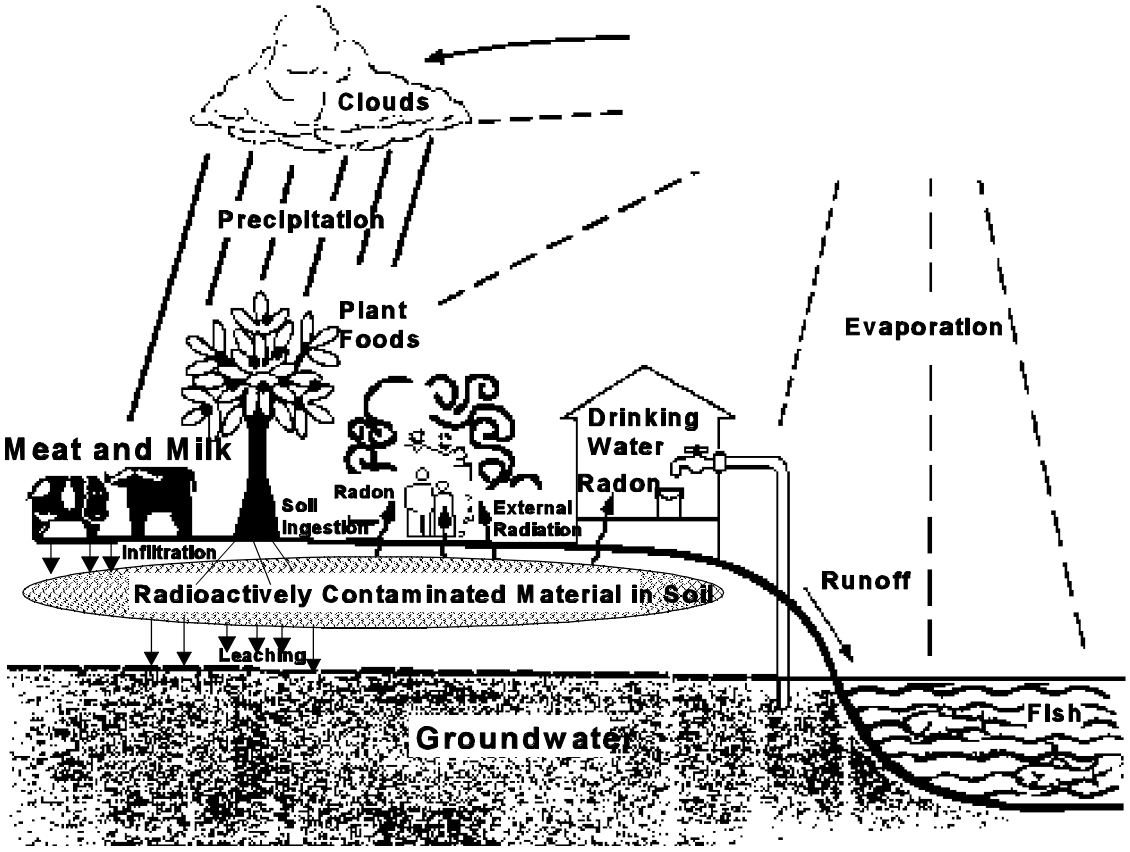
Scenario A — Represents typical exposures to a worker onsite. The individual does not drink water onsite or produce food for his/her personal consumption.

Scenario B — Represents a typical residential exposure for a homeowner who spends most of the time onsite. This individual also ingests drinking water, produced from a groundwater well onsite, as well as food grown in a garden onsite to supplement the diet.

Scenario C — This scenario is intended to represent the maximum reasonably exposed individual. Because the scenario is based on "prudently conservative" assumptions that tend to overestimate potential doses, use of this scenario should result in estimated doses that will be greater than the exposure to future residents most of the time. This individual spends long periods of time outside the residence (21% spends five hours per day for 365 days), grows and ingests a large percentage of vegetables from the onsite garden, consumes meat and milk produced onsite, and consumes aquatic food from a neighboring pond near the site.

These exposure scenarios can be readily assessed using commonly available computer codes, such as RESRAD. The RESRAD computer code is currently one of several codes used to independently estimate doses associated with residual radioactive contamination.

Figure 3
Exposure Pathways



When a site is remediated, part of the problem is the radioactive waste. As indicated by its title, DOE Order 5820.2A, *Radioactive Waste Management,* establishes policies, guidelines, and minimum requirements for DOE's management of its radioactive and mixed waste and contaminated facilities. Following is a summary of this document:

DOE Order 5820.2A, *Radioactive Waste Management*	
Purpose	Establishes policies, guidelines, and minimum requirements by which DOE manages its radioactive and mixed waste and contaminated facilities.
Scope	Applies to all DOE elements, and, as required, all DOE contractors and subcontractors performing work that involves management of radioactive waste and/or radioactively contaminated facilities for DOE.

DOE Order 5820.2A, *Radioactive Waste Management* (cont.)	
Requirements/ Key Words	Chapter I, High-Level Waste (HLW) • Establishes policies and guidelines for managing HLW; subject to Atomic Energy Act (AEA) and the Resource Conservation and Recovery Act (RCRA). • All HLW generated by DOE operations shall be safety stored, treated, and disposed of according to DOE Order 5820.2A. Storage operations shall comply with Environmental Protection Agency (EPA) standards and EPA/state regulations. Geologic disposal shall comply with both Nuclear Regulatory Commission (NRC) regulations and EPA standards. • Requirements - Design requirements for new facilities and design review for existing facilities - Storage operations for doubly contained systems - waste characterization; storage and transfer operations; monitoring, surveillance, and leak detection; contingency action; training; quality assurance; and waste treatment and minimization - Storage operations for singly contained tank systems - waste characterization; storage and transfer operations; monitoring, surveillance, and leak detection; contingency action; training; and quality assurance - Disposal of new and readily retrievable existing HLW and other waste Chapter II, Management of Transuranic (TRU) Waste • Establishes policies and guidelines for managing DOE TRU waste starting with its generation, continuing through closure of the Waste Isolation Pilot Plant (WIPP), and finally ending with the management of buried TRU waste. TRU wastes that are also mixed wastes are subject to AEA and RCRA requirements. Buried TRU wastes are subject to the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA). • TRU waste shall be managed to protect the public, worker health and safety, and the environment; and management shall be performed in compliance with radiation protection and environmental standards. • Requirements - Waste classification - TRU waste generation and treatment - TRU waste certification and packaging - Temporary storage at generating sites - Transportation/shipping to the WIPP - Interim storage designation and new interim storage-facility requirements - WIPP - Buried TRU-contaminated waste - Quality assurance

DOE Order 5820.2A, *Radioactive Waste Management* (cont.)	
Requirements/ Key Words (cont.)	Chapter III, Management of Low-Level Waste (LLW) • Establishes policies, requirements, and guidelines for managing DOE's solid LLW. • LLW operations shall be managed to protect the health and safety of the public, using waste-generation reduction, segregation, treatment, and disposal practices to maximize cost-effectiveness. LLW will be disposed of on the site of generation if possible or at another DOE disposal facility, and mixed waste will conform to appropriate orders and regulations. • Requirements - Performance objectives to protect public health and safety and the environment - Performance assessment to demonstrate compliance with stated objectives - Waste generation requirements to reduce the volume of waste and/or amount of radioactivity requiring disposal - Waste characterization to permit proper segregation, treatment, storage, and disposal - Waste-acceptance criteria - Waste treatment, shipment, long-term storage - Disposal, disposal site selection, disposal facility and disposal site design - Disposal facility operations, site closure/postclosure - Environmental monitoring, quality assurance, and records and reports Chapter IV, Management of Waste Containing Naturally-Occurring and Accelerator-Produced Radioactive Material (AEA 11e(2) By-product Materials) • Establishes policies and guidelines for managing DOE waste containing by-product material, as defined by section 11e(2) of the Atomic Energy Act of 1954, as amended, and naturallyoccurring and accelerator-produced radioactive material. • DOE wastes of this category shall be stored, stabilized in place, and/or disposed of consistent with 40 CFR 192 guidelines. Small volumes of DOE waste containing 11e(2) by-product material may be managed as low-level waste in accordance with Chapter III of this Order. (If mixed waste, management must also comply with RCRA.) • Requirements for waste management and quality assurance. Chapter V, Decommissioning of Radioactively Contaminated Facilities • Establishes policies and guidelines for the management, decontamination, and decommissioning of radioactively contaminated facilities under DOE ownership and control. • Radioactively contaminated DOE facilities shall be managed in a safe, cost-effective manner to ensure that release of and exposure to radioactivity and other hazardous materials comply with Federal and state standards. Facilities, equipment, and valuable materials shall be recovered and reused when practical.

DOE Order 5820.2A, *Radioactive Waste Management* (cont.)	
Requirements/ Key Words (cont.)	Chapter V, Decommissioning of Radioactively Contaminated Facilities (cont.) • Requirements - General program development and documentation - Facility design - Postoperational activities include potential for reuse and recovery of materials and equipment based on maintaining employee and public health and safety, environmental protection, and compliance with Federal and other requirement - Decommissioning project activities include facility characterization, environmental review processes, engineering planning, operations, and postdecommissioning activities - Quality assurance requirements include compliance with national consensus standards such as the American National Standards Institute (ANSI) and the American Society of Mechanical Engineers (ASME) Chapter VI, Waste Management Plan Outline • Provides guidance on the development and maintenance of a waste management plan for each site that generates, treats, stores, or disposes of DOE waste. • Discussion - The primary purpose of the waste management plan is to compile and consolidate an annual report on how waste management operations are conducted, what facilities are being used to manage wastes, what forces are acting to change current waste management systems, and what plans are in store for the coming fiscal year. • Format for waste management plans - Executive summary - General site information such as organization and site description - Radioactive and mixed waste management operations, systems, facilities, waste characteristics, problems, recommendations, and future direction of the site operations - Hazardous waste management (Defense Program [DP] facilities) - Schedule and cost summary - Environmental monitoring programs - Related subjects Attachments • References • Definitions

The following section is the Introduction section from the *Decommissioning Resource Manual*. The introduction includes a good summary of the document and each chapter. To obtain a copy of this document, contact:

Remedial Action Program Information Center (RAPIC)
138 Mitchell Road
Oak Ridge, TN 37830-7918
phone: (423)576-6500
FAX: (423)576-6547
E-mail: rapic@ornl.gov

DOE/EM-0246, *DECOMMISSIONING RESOURCE MANUAL*

Introduction: Purpose and Scope of this Resource Manual

Purpose

The purpose of this Resource Manual is to provide a reference resource for the Department of Energy (DOE) decommissioning program conducted by the Office of Environmental Restoration (EM-40). The manual provides information to assist in the effective implementation of the Decommissioning Framework specified in the *Environmental Restoration Program Decommissioning Implementation Guide*, May 22, 1995 (included as Appendix A of this manual). The *Implementation Guide* and the Framework it describes are consistent with the *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, May 22, 1995 (included as Appendix B of this manual). This manual provides background on the development of decommissioning policy and the framework, identifies decommissioning steps, suggests contents of documents, provides suggested decommissioning practices, describes the respective roles of DOE Headquarters and field organizations, and provides additional information on a variety of decommissioning functional topics.

The DOE decommissioning framework is modeled after the process for conducting CERCLA non-time-critical removal actions, as specified in the National Oil and Hazardous Substances Pollution Contingency Plan (40 *CFR* 300), commonly referred to as the National Contingency Plan (NCP). However, the basic framework is flexible enough to accommodate all DOE decommissioning projects, regardless of the statute, authority, or management decision which initiates the project. As discussed in various sections of this manual, a decommissioning project may be initiated by a variety of circumstances, including:

- Determination that a release or substantial threat of release to the environment is present, and a removal action under CERCLA is appropriate;
- Implementation of an NRC-approved decommissioning plan, with the objective of termination of an NRC license;
- Decommissioning in accordance with a RCRA permit or order; and
- DOE programmatic management decision to proceed with the disposition of a contaminated surplus facility (having determined that no release or threat of release warrants a response under CERCLA).

The flow charts contained in Appendix C of this manual illustrate that the basic decommissioning framework satisfies the requirements of these potential drivers. However, each driver may raise specific environmental compliance issues which must be addressed **within** this uniform framework.

The reader of this initial release of the Decommissioning Resource Manual should be aware of a number of factors which may affect some features of the document. Principal **among these** factors are the potential reorganization or realignment of the Office of Environmental Management (EM); and the work in progress to consolidate a number of safety-related DOE orders (led by the Office of Environment, Safety and Health - EH) and orders related to the management of physical facilities (led by the Office of Field Management - FM).

The provisions of this manual are intended to replace the programmatic (nontechnical) suggestions found in Chapters 2 through 5 of the Decommissioning Handbook (document number DOE/EM-0142; March, 1994).

A revision of the Resource Manual is planned for the near future after field decommissioning planners and managers have had an opportunity to work with the document and to provide comments.

Scope of the Resource Manual

This manual focuses on management and programmatic issues rather than technical decommissioning issues, which are treated in the Decommissioning Handbook. The scope of this manual is as follows:

Chapter 1 - Introduction, gives a history of the DOE decommissioning program, describes the current decommissioning policy and the conduct of decommissioning as a removal action when CERCLA applies, and describes the roles of Headquarters and the field organization.

Chapter 2 - The Decommissioning Framework, describes the actions taken in the various steps in the decommissioning framework, suggests certain practices to be employed, and gives suggestions on the contents of documents.

Chapter 3 - Facility Transition, describes the facility transition, deactivation, and acceptance processes and identifies other relevant sources of information, from the EM-40 point of view.

Chapter 4 - Surveillance and Maintenance (S&M), describes S&M program objectives and identifies roles of organizations, documentation, and other sources of information.

Chapter 5 - Closeout, Verification, and Release Process, describes the process for closeout, verification, and release of decommissioning removal action sites and identifies the documentation.

Chapter 6 - Environmental Compliance, describes the major statutes and regulations applicable to the decommissioning process and assesses the impact of these requirements on decommissioning removal action projects.

Chapter 7- Health and Safety, describes health and safety priorities, responsibilities, and occupational safety and health (OSH) requirements

Chapter 8 - Project Management, summarizes and outlines the basic project management approach and identifies other sources of information.

Chapter 9 - Waste Management, describes how decommissioning residue material is to be planned for, minimized, and disposed in compliance with DOE regulations.

The Appendices contain useful reference material pertaining to the decommissioning process.

Decommissioning Program Background

Central Program - Surplus Facilities Management Program (SFMP)

Prior to 1979, DOE had no central decommissioning program. Focused programs had been established at Grand Junction, Colorado, at Uranium Mill Tailings Sites (UMTRA Program), and at Former Manhattan Project Sites (FUSRAP). In 1979, the Surplus Facilities Management Program (SFMP) was established in Richland, WA for the coordinated management of the decommissioning of surplus contaminated DOE facilities. The Richland Program Office issued the *SFMP Resource Manual* to serve as the management guide. The principal directive for the program was DOE Order 5820.2 *Radioactive Wastes Management.* Release criteria were established on a case-by-case basis in conformance with DOE Order 5400.5 *Radiation Protection of the Public and the Environment.* The legal precedent was the authority granted to the Atomic Energy Commission and successor organizations (i.e., DOE) under the Atomic Energy Act (AEA) of 1954 to protect the health and safety of the public against radiation while conducting the Department's programs.

Civilian and Defense Programs

In 1982 the single program was divided. The civilian (or nuclear energy) program continued to be managed by the SFMP, relocated to DOE Headquarters in Washington, D.C. For surplus facilities from the national defense programs, decommissioning was directed through the Defense Facilities Decommissioning Program Office located in Richland.

The *SFMP Resource Manual* continued to be the principal management guidance for the civilian program. The defense program issued the *Defense Decontamination and Decommissioning Program: Program Management Plan* (DOE/RL-89-23).

Office of Environmental Restoration and Waste Management

In 1989, the Office of Environmental Restoration and Waste Management was established and the two programs were again combined - now under Headquarters geographical area offices, which were responsible for both soil/water body environmental restoration (remedial action) and decommissioning. The two management documents remained in effect, with some updating by area offices. The current EM title is the Office of Environmental Management.

Environmental Management Decommissioning Policy

The Comprehensive Environmental Response. Compensation. and Liability Act (CERCLA)

CERCLA provides expansive authority to the federal government to protect human health and the environment from the risks posed by hazardous substances (including most radionuclides). Response actions are guided by the NCP, codified in the Code of Federal Regulations (CFR) at Title 40, Part 300 (or simply 40 *CFR* 300). The NCP outlines the steps federal agencies follow in responding to situations in which oil is discharged or there is a threat of discharge into the environment; or hazardous substances, pollutants, or contaminants, are released, or threatened to be released, into the environment. Under authority of CERCLA and the NCP, many DOE sites are on the National Priorities List (NPL) for long-term clean up programs.

Development of Policy

In 1994, the Secretary of Energy determined it was inappropriate for the Department to be self-regulating in the performance of decommissioning and that provisions of CERCLA should apply when appropriate.

A working group between DOE and the U.S. Environmental Protection Agency (EPA) was formed to establish the manner of applying CERCLA to decommissioning. Personnel from both Headquarters and the field in the two agencies participated. The result of this effort was the *Policy on*

Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), signed on May 22, 1995, by the assistant administrators at EPA's Office of Enforcement and Compliance Assurance and Office of Solid Waste and Emergency Response, and by DOE's Assistant Secretary for Environmental Management. The policy is consistent with, and builds upon the EPA/DOE/DOD *Guidance an Accelerating CERCLA Environmental Restoration at Federal Facilities,* Aug. 22, 1994, provided as Appendix D of this manual.

The policy establishes that decommissioning activities will be conducted as non-time-critical removal actions under CERCLA, unless the circumstances at the facility make it inappropriate (see the discussion of other drivers in Section 1.1.1 above). Use of non-time-critical removal actions for conducting decommissioning activities effectively integrates EPA oversight

The following section is the Introduction section from the *Decommissioning Handbook*.

Please be reminded that the provisions of the *Decommissioning Resource Manual* are intended to replace the programmatic (nontechnical) suggestions found in Chapters 2 through 5 (emphasized with a shaded box) of this document.

DOE/EM-0142P, *DECOMMISSIONING HANDBOOK*

Introduction: Handbook Purpose

The *Decommissioning Handbook* has been prepared under contract to the U.S. Department of Energy (DOE) to provide technical guidance on the decommissioning—commonly known as *decontamination and decommissioning (D&D)* of commercial and governmental nuclear facilities. Because of the unique hazards incumbent in nuclear facilities, their design, licensing, and startup (commissioning) require a stepwise program to address safety. Similarly, because of residual radioactivity, the termination of operations (decommissioning) presents unique hazards that must be addressed from a programmatic, safety, environmental, and technological standpoint. This handbook provides technical guidance for decommissioning activities, including characterization, decontamination, dismantling, and disposition (disposal or salvage) of a facility's equipment and structures. Waste treatment is also considered a decommissioning activity, depending on the regulatory requirements for material disposal and/or the wastes generated by decontamination. In addition to technical guidance, this document provides an overview of the decommissioning process, including planning, applicable regulations, and supporting activities (e.g., transportation and worker and environmental protection). This overview explains the background and organization of this document, briefly mentions the technical subjects addressed, and reviews the peripheral (nontechnical) considerations that must be addressed during a decommissioning project.

This document does not contain requirements that have to be followed during decommissioning, nor does it identify the administrative coordination that must be established with regulatory bodies. Nuclear facilities located in the United States of America are regulated by a variety of agencies: DOE regulates governmental facilities; the U.S. Nuclear Regulatory Commission (NRC) oversees most commercial facilities; and state regulatory agencies are responsible for other commercial facilities. Thus, a complete description of the regulatory environment applicable to all nuclear facilities is beyond the intent of this handbook. Nonetheless, applicable regulations that contain these requirements and coordination needs are identified.

The technical guidance provided herein includes a description of state-of-the-art mechanical and chemical processes available for decommissioning. This guidance is intended to provide a compendium of available or potentially available technologies as an aid so that the most appropriate ones can be selected to meet the specific needs of each decommissioning project.

This handbook is primarily a technology identification document; thus, the chapters identifying technologies are the focus of the handbook. To encompass the entire decommissioning project—including detailed planning requirements, funding, estimating, and decommissioning operations—is far beyond the scope of this handbook. The reader is referred to other documents for details involving these important elements of a total decommissioning project. Some of these documents are the DOE orders concerning D&D and cost estimation, the proposed guidance document under preparation for DOE headquarters, applicable NRC regulations, and the pending codification of DOE orders regarding decommissioning in Title 10 of the Code of Federal Regulations (10 CFR).

The Remedial Action Program Information Center (RAPIC) provided research information on D&D to support the development of this handbook. RAPIC, a support group to the DOE Office of Environmental Restoration (ER) (EM-40), provides technical information support to all DOE ER programs, program participants, and the scientific community involved in environmental restoration activities. The use of RAPIC or other databases is recommended to obtain the most current information available for a specific technology described in this handbook or identified as part of an individual decommissioning project.

The *Decommissioning Handbook* was prepared concurrently with a guidance document that provides specific programmatic guidance for planning decommissioning for DOE-owned facilities. The programmatic guidance outlines the full DOE planning process for decommissioning. The technologies and methods outlined in this handbook can be used in concert with the guidance document to arrive at a comprehensive plan for a decommissioning project. The handbook was prepared as a tool to allow the reader to efficiently research decommissioning technologies by providing a single convenient resource.

For the purpose of this handbook, and as described in Sections 5.l and 5.2.3, decommissioning is assumed to begin after the spent nuclear fuel has been removed from reactors and processed inventories of high-level radioactive waste have been removed from nonreactor facilities.

Handbook Background

The original *Decommissioning Handbook* was prepared in 1980 by Nuclear Energy Services (NES) under contract to DOE. This new *Decommissioning Handbook* represents a restructuring of the original handbook, to address significant technological advances and additional topics, including the following:

1. project planning,
2. regulatory requirements,
3. characterization,
4. remote technology, and
5. packaging and transportation.

The discussion of project planning in this handbook is general and can apply to both DOE-owned and non DOE-owned facilities. The guidance document provides a more detailed, DOE-specific approach to project planning for decommissioning.

Because this handbook is a revision of the one authored by NES, material quoted, paraphrased, or summarized from the original is not delineated in the text by a reference. However, references cited in the original handbook have been transferred to this revision.

Handbook Organization

The *Decommissioning Handbook* consists of fifteen chapters, each of which focuses on a different aspect of the decommissioning process, and one appendix. Together these chapters provide a comprehensive technical guide for decommissioning activities. The handbook employs the author-date method for citing references, and references used within a chapter are listed at its end. It is the intent of the handbook to serve as a comprehensive, on-going reference manual. Therefore, references are also included which might serve as a source of further information to the user. Although these references are not necessarily cited within the text, they will function as a roadmap to additional information on the decommissioning process. A brief description of each chapter follows.

Chapter l, Introduction—Introduces the reader to the *Decommissioning Handbook,* describes its purpose, provides its production background, and outlines its overall organization.

Chapter 2, Operational and Predecommissioning Activities—Explains the concept of facilitation, in which operations during the normal plant life affect the decommissioning and how these operations can ease the task of decommissioning. The aspects discussed include facility design, normal operations, maintenance and periodic shutdown procedures, safe shutdown, and surveillance and maintenance (S&M) (if required) between safe shutdown and decommissioning. This chapter also discusses the items in safe shutdown that should normally precede any decommissioning work.

Chapter 3, Decommissioning Project—Identifies the elements of the decommissioning project, which are broken down into four phases: assessment, development, operations, and closeout, A summary of considerations that should be included in each of these phases is presented.

Chapter 4, Decommissioning Plan—gives an outline of the information that is required in the decommissioning plan in accordance with DOE requirements and commercial regulations.

Chapter 5, Regulatory Requirements—Identifies the federal regulatory bodies that govern the use and transportation of radioactive and hazardous materials and mixed waste. Applicable sections from DOE orders that govern decommissioning of government-owned facilities are listed, as are U.S. Department of Transportation (DOT) and NRC regulations. In addition, brief comments are made regarding appropriate legislative acts, enforced by the U.S. Environmental Protection Agency (EPA).

Chapter 6, Final Project Configuration—Emphasizes the importance of defining the final project configuration at the start of the planning process. The difference between the initial and final configurations determines the material that must be disposed of during decommissioning. This information is shown to be basic to the definition of a characterization program.

Chapter 7, Characterization—Discusses the information gathering process (most often involving sampling and measurement) used throughout the decommissioning project. Characterization is needed from the time of the preliminary assessment of site hazards through the detailed measurements supporting engineering and waste certification to the final site survey. Guidance is provided for developing a characterization plan, and measurement technologies are described that are adaptable for use in the field or in a laboratory on a decommissioning site.

Chapter 8, Waste Treatment—Discusses various waste treatment methods and equipment for various waste streams. Waste may be present at the start of decommissioning or may be generated by decontamination activities.

Chapter 9, Decontamination—Identifies various chemical, mechanical, or other technologies that are available for decontaminating equipment and structures at a decommissioning site. A description of the process and its potential applications is provided. The techniques presented vary, from common practices to emerging technologies.

Chapter 10, Dismantling, Segmenting, Demolition—Presents techniques that can be used to dismantle (i.e., physically remove material from a building), segment (i.e., divide components into pieces), and demolish a facility. For each technique identified, a description of the process and its applications is presented. Techniques presented vary, from the use of common hand tools to emerging technologies that are currently under development.

Chapter 11, Remote Handling Equipment and Operations—Describes remote technologies that can be used in a decommissioning project. Examples are provided showing how remote technology has been utilized in past decommissioning projects. The rationale for choosing remote technology and the ranges of its application are discussed.

Chapter 12, Worker Protection—Highlights the importance of worker protection, explains the difference between worker protection at a decommissioning project and at other types of projects, and identifies the issues necessary to ensure that worker protection is properly implemented during decommissioning.

Chapter 13, Environmental Protection—Discusses regulatory standards and protective measures for air, surface water, and groundwater, as well as site release criteria and environmental monitoring.

Chapter 14, Packaging and Transportation—Stresses the importance of packaging and transportation in decommissioning and presents an overview of packaging and transportation of radioactive, hazardous, and mixed waste. Identifies the federal regulatory bodies that govern these activities, as well as the regulations; however. this chapter is not to be used as a substitute for the regulations themselves.

Chapter 15, Decommissioning Cost Estimates and Schedule—Presents the key elements that are required to prepare a cost estimate and project schedule. A methodology is also presented that shows how these elements are related.

Appendix, Estimation of Radioactive Inventory—Provides information that the reader can use to predict the quantities and identities of radioactive materials in the facility. The appendix includes the calculation of activation of materials under neutron bombardment, discusses transport of radioactive materials from the source throughout the facility, and describes methods for calculating the resulting radiation dose rates. The appendix also describes verification of the calculated results by actual measurement and it provides a method to estimate inventory based on field measurements.

Glossary—Includes a glossary of governmental and industrial terms used in this handbook.

3. SELF-STUDY SCENARIOS/ACTIVITIES AND SOLUTIONS

Activity 1

Complete the following summary of exposure pathways table for Scenarios A, B, and C (found on p. RP 2.9-8) with a "Yes" or "No" to indicate if each of the pathways apply to each of the scenarios.

Pathway	**Scenario A**	**Scenario B**	**Scenario C**
Example: External Exposure	Yes	Yes	Yes
Inhalation (Resuspension)			
Radon Inhalation			
Ingestion of Groundwater			
Ingestion of Vegetables			
Ingestion of Meat			
Ingestion of Milk			
Ingestion of Aquatic Food			
Ingestion of Soil			

Activity 2

In order to increase your familiarity with DOE Order 5820.2A, review the Order to locate answers to the following questions. List your findings on the chart below.

Questions	Answer Location in DOE 5820.2A
Example: What are the responsibilities of Assistance Secretary for Environment, Safety and Health (EH-1)?	Section 8.e.
1. What is LLW?	
2. What are the objectives of the DOE LLW program?	
3. What principal waste management documentation is required?	
4. What is required in a waste management plan?	
5. What is DOE's policy on HLW?	
6. What are the evaluation requirements for HLW that is not retrievable?	
7. When should material suspected of being contaminated with TRU radionuclides be evaluated?	
8. Who is responsible for certifiability of the waste form; waste package content; and proper marking, labeling, and placarding of a shipment from an interim storage site to WIPP?	
9. Where are large quantities of LLW (by-product) allowed to be disposed?	
10. What federal regulations govern decommissioning project activities?	
11. Where is waste minimization addressed for DOE LLW generators? (3 Sections)	
12. What documentation must be prepared after decommissioning operations are completed?	

Activity 1, Solution

Pathway	**Scenario A**	**Scenario B**	**Scenario C**
External Exposure	Yes	Yes	Yes
Inhalation (Resuspension)	Yes	Yes	Yes
Radon Inhalation	Yes	Yes	Yes
Ingestion of Groundwater	No	Yes	Yes
Ingestion of Vegetables	No	Yes	Yes
Ingestion of Meat	No	No	Yes
Ingestion of Milk	No	No	Yes
Ingestion of Aquatic Food	No	No	Yes
Ingestion of Soil	No	Yes	Yes

Activity 2, Solution

Questions	Answer Location in DOE 5820.2A
Example: What are the responsibilities of Assistance Secretary for Environment, Safety and Health (EH-1)?	Section 8.e.
1. What is LLW?	Attachment 2, Page 3, #20 (Definitions)
2. What are the objectives of the DOE LLW program?	Chapter III-1, Section 3.a. (Performance Objectives)
3. What principal waste management documentation is required?	Attachment VI-1, Page 5
4. What is required in a waste management plan?	Chapter VI (Waste Management Plan Outline)
5. What is DOE's policy on HLW?	Chapter I-1, Section 2. (Policy)
6. What are the evaluation requirements for HLW that is not retrievable?	Chapter I-8, Section 3.d.(2)
7. When should material suspected of being contaminated with TRU radionuclides be evaluated?	Chapter II-1, Section 3.a.(1)
8. Who is responsible for certifiability of the waste form; waste package content; and proper marking, labeling, and placarding of a shipment from an interim storage site to WIPP?	Chapter II-8, Section 3.g.(7)(c)
9. Where are large LLW (by-product) allowed to be disposed?	Chapter IV-1, Section 3.a.(1) and (2)
10. What federal regulations govern decommissioning project activities?	Chapter V-3, Section 3.d.(1), (2), and (3)
11. Where is waste minimization addressed for DOE LLW generators? (3 Sections)	Chapter III-1, Section 2.b. Chapter III-2, Section 3.b.(2) Chapter III-2-3, Section 3.c.(1), (2), and (4)
12. What documentation must be prepared after decommissioning operations are completed?	Chapter V-5, Section 3.d.(5)(a) and (b)

4. SUGGESTED ADDITIONAL READINGS AND/OR COURSES

Readings

- ORO-831, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program.*
- ANL/EAD/LD-2, *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.61.*
- DOE 5820.2A, *Radioactive Waste Management***.**
- U.S. Nuclear Regulatory Commission (1994). *Scenarios for Assessing Potential Doses Associated with Residual Radioactivity* (PG-8-08).
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*
- 10 CFR 834, *Radiation Protection of the Public and the Environment; Proposed Rule.*

Courses

- *DOE Facility Deactivation, Decontamination, and Decommission Dismantlement* -- DOE.
- *Radiological Surveys in Support of Decommissioning* -- Oak Ridge Institute for Science and Education.
- *Radiation Protection Functional Area Qualification Standard Training* -- GTS Duratek.

Questions

- RESRAD code:
  Telephone - Charlie Yu, (708) 252-5589
  E-mail: RESRAD@ANL.GOV

- Remedial Action Program Information Center (RAPIC)
  138 Mitchell Road
  Oak Ridge, TN 37830-7918

  Telephone: (423)576-6500

  FAX: (423)576-6547
  E-mail: rapic@ornl.gov